Schneider Kreuznach PC Tilt/Shift Lenses

User Manual

PC-TS SUPER-ANGULON 2.8/50 HM
PC-TS MAKRO-SYMMAR 4.5/90 HM

with interchangeable bayonet mount for Canon EOS, Nikon, Pentax K or Sony Alpha

PC-TS APO-DIGITAR 5.6/120 HM Aspheric

with bayonet mount for Mamiya / Phase-One System

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Schneider Kreuznach PC Tilt/Shift Lenses

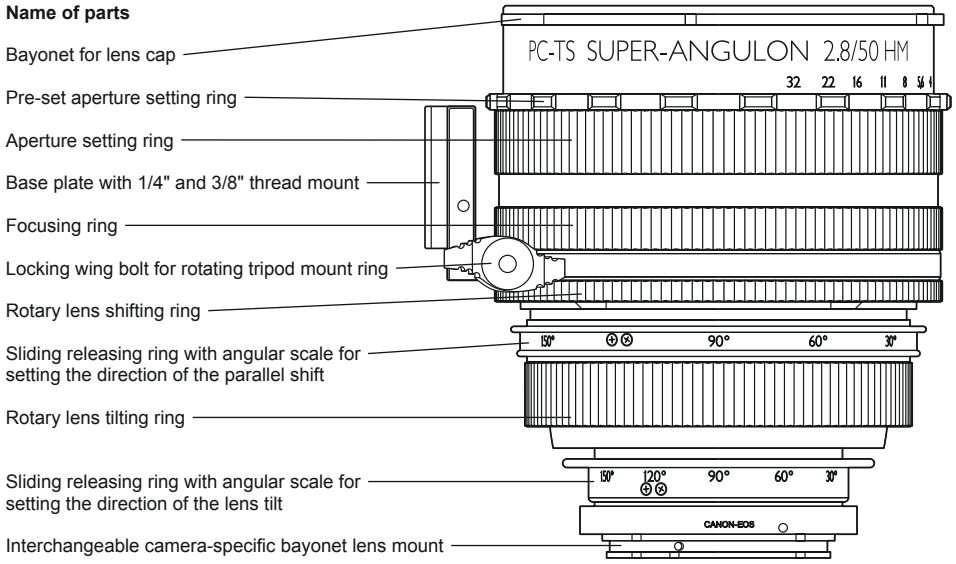
Congratulations! You have made the right choice.

You have purchased a PC-TS lens from Schneider-Kreuznach because you want the best possible image reproduction quality while having the option to correct perspective and to enjoy greater depth of field through tilting according to Scheimpflug's principle.

Your new PC-TS lens (PC = perspective control; TS = tilt & shift) allows both a parallel shift to reduce or even completely eliminate converging lines or perspective distortion ("keystone correction") and a swinging or tilting of the lens according to Scheimpflug's rule in order to better utilize depth of field (DOF) without an increase in diffraction from further stopping down the aperture and reducing sharpness. Parallel shift and lens swing or tilt can be carried out independently of one another in any desired direction (vertically, horizontally or obliquely) thanks to separate rotary mounts.

This also provides you with the advantages usually associated with adjustable technical cameras to a degree sufficient for most applications with your single-lens reflex camera (simpler and faster). You no longer have to spend a lot of time on the computer correcting the keystone effect, with the accompanying loss of sharpness (see page 8); and thanks to the Scheimpflug tilt, you no longer have to stop down to achieve sufficient DOF (see page 9). This manual will help you make optimum use of the advantages of your new lens.

Name of parts



The PC TS lenses 4.5/90 HM and 5.6/120 HM are built exactly like the 2.5/50 HM shown above up to the tripod mount ring. Only because of their longer focal length are their focusing rings, aperture setting rings and pre-set aperture setting rings positions slightly different.

Pre-set aperture:
Set the working aperture with the aperture setting ring. Open the aperture with the blue pre-set aperture setting ring for framing and focusing. Then stop down with this blue ring before releasing the shutter.

Extra-large image circle for shift and tilt

The image circle diameter of normal lenses is only slightly larger than the diagonal of the taking format, e.g. 44 mm with a full frame 35 mm format which has a diagonal of 43.3 mm. It is thus ensured that there is no vignetting (darkening) in the image corners.

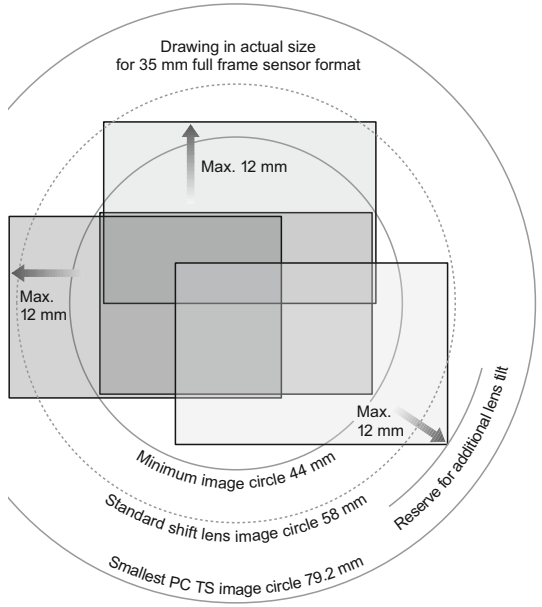
However, the PC-TS lenses have a much larger image circle of 79.2 mm (2.8/50 HM), 87.8 mm (4.5/90 mm HM, both for the full frame 35 mm format) and 153 mm (5.6/120 HM for formats up to 45 mm x 60 mm). This gives you enough freedom for parallel shift and Scheimpflug swing or tilt up to the mechanical limit defined by the aperture of the camera bayonet mount even when parallel shift and swinging or tilting are carried out in any direction simultaneously.

Conventional shift lenses for the 35 mm format with an image circle diameter of usually approximately 58 mm allow for vignetting free shift of 10.7 mm in landscape mode, but only 8.4 mm in portrait mode. The PC-TS 35 mm lenses allow 12 mm in both orientations, that is almost 50 % more shift in the portrait mode which is particularly important for tall objects like buildings.

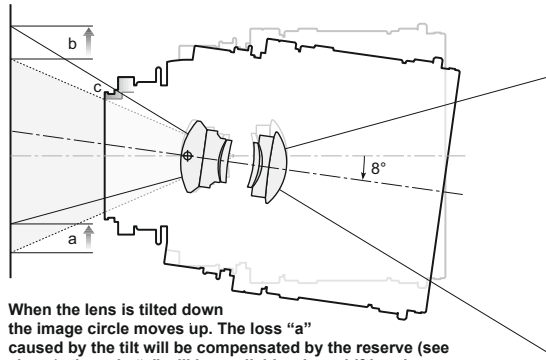
As the full-scale drawing on the right shows, there are still sufficient reserves for any additional lens swing or tilt according to Scheimpflug for better utilization of DOF even with a diagonal shift of 12 mm (which would only be possible by 7.3 mm with a lens of 58 mm image circle diameter).

Angled shots of objects with vertical edges are no less problematic with regard to converging lines than architectural shots typically associated with this type of photography. However, due to the much shorter taking distance for product shots, a much smaller DOF results and makes it necessary to stop down even further which results in unwanted diffraction blur. It is only possible to stop down less by using lens tilt according to Scheimpflug (see page 9). Because the lens has to be tilted downward, the image circle moves upward, in the opposite direction to the parallel shift to remedy the converging lines. This reduces the total shift.

If, however, the upward parallel shift is combined with a downward Scheimpflug tilt for building shots, the upward image circle displacements are summed. The enormous image circles of all three PC-TS lenses are equal to this task.



The image circle of all PC TS lenses is larger than necessary for parallel shifts only. This is due to have a reserve for additional lens tilts according to the Scheimpflug rule.



When the lens is tilted down the image circle moves up. The loss "a" caused by the tilt will be compensated by the reserve (see above); the gain "c" will be available when shifting down.

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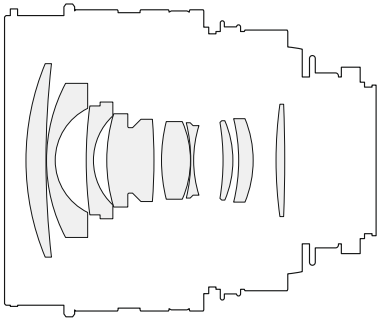
PC-TS SUPER-ANGULON 2.8/50 HM

This lens has a standard focal length for a full frame 35 mm format and produces perspectives which appear very natural. It is therefore recommended mainly for architectural photography as well as for town and landscape imagery. It is also suitable for product shots which require a much greater depth effect (greater spatial perspective) than is possible with a longer focal length lens otherwise preferred for this purpose. With parallel shifting, buildings can be reproduced without converging lines up to 100 % higher (= twice as high) above the horizon in landscape format or up to 67 % higher in portrait format than with lenses of the same focal length without such a shift option.

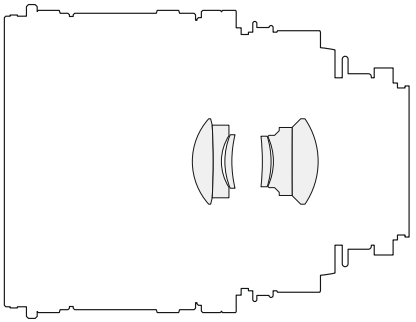


Specifications

Effective focal length	51.75 mm
Optical design	9 elements in 9 groups
Coating	MC (multicoating)
Max. sensor format	24 mm x 36 mm
Image circle diameter	79.2 mm (at infinity)
Maximum shift reserve	12 mm in every direction
Maximum tilt angle	8° in every direction
Focusing	manually
Nearest distance	0.65 m from sensor plane
Largest image scale	1:9.2 (w/o accessories)
Smallest subject size	220 mm x 330 mm
Aperture setting	manually, pre-set setting ring
Aperture setting range	2.8 to 32 in 1/3 EV steps
Filter/accessory mount	M 95 x 1 and bayonet VIII
Lens shade	Accessory, threaded
Total length	128.4 mm (EOS bayonet)
Maximum diameter	108 mm (w/o tripod mount)
Weight	1400 g
Tripod mount thread	3/8" and 1/4", 360° rotary
Available camera monts	Canon EOS, Nikon, Sony Alpha, Pentax K

PC-TS MAKRO-SYMMAR 4.5/90 HM

This lens with a focal length of 90 mm is the ideal solution for product shots with full frame 35 mm format. The slightly longer focal length creates a longer taking distance for arranging the subject and provides extra space for the lighting. The narrower angle of view means that the backgrounds do not have to be so wide. The sharpness is excellent throughout the focus range to enable shots of very small objects (smallest format-filling object field 142 mm x 95 mm) with the long helical mount; in addition, the Scheimpflug tilt ensures a much better DOF and the parallel shift provides more attractive product shots without converging lines or with greatly reduced converging lines.

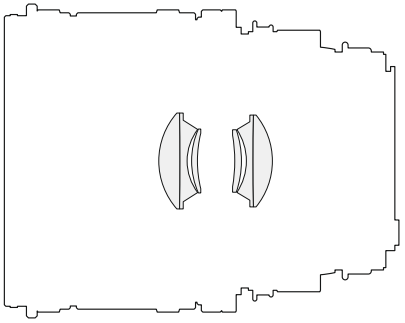


Specifications

Effective focal length	90.72 mm
Optical design	6 elements in 4 groups
Coating	MC (multicoating)
Max. sensor format	24 mm x 36 mm
Image circle diameter	87.8 mm (at infinity)
Maximum shift reserve	12 mm in every direction
Maximum tilt angle	8° in every direction
Focusing	manually
Nearest distance	0.57 m from sensor plane
Largest image scale	1:4 (w/o accessories)
Smallest subject size	95 mm x 143 mm
Aperture setting	manually, pre-set setting ring
Aperture setting range	4.5 to 32 in 1/3 EV steps
Filter/accessory mount	M 95 x 1 and bayonet VIII
Lens shade	Integrated (recessed lens)
Total length	138.8 mm (EOS bayonet)
Maximum diameter	108 mm (w/o tripod mount)
Weight	1110 g
Tripod mount thread	3/8" and 1/4", 360° rotary
Available camera monts	Canon EOS, Nikon, Sony Alpha, Pentax K

PC-TS APO-DIGITAR 5.6/120 HM ASPHERIC

This apochromatically corrected lens for the digital medium format of the Mamiya/Phase-One system provides the adjustment possibilities of professional technical cameras. Depending on the digital back used (in formats from 33 mm x 43 mm to 40 mm x 54 mm), the focal length corresponds to the 35 mm equivalent of 98 mm to 80 mm. The PC-TS APO DIGITAR 5.6/120 HM is therefore ideal for product shots and satisfies the highest demands thanks to its high resolution and exceptional image quality. The parallel shift and the Scheimpflug swing and tilt ensure a perfect perspective and maximum DOF.



Specifications

Effective focal length	123.62 mm
Optical design	6 elements in 4 groups
Coating	MC (multicoating)
Max. sensor format	45 mm x 60 mm
Image circle diameter	153 mm (at infinity)
Maximum shift reserve	12 mm in every direction
Maximum tilt angle	8° in every direction
Focusing	manually
Nearest distance	0.84 m from sensor plane
Largest image scale	1:5.3 (w/o accessories)
Smallest subject size	depending in the digital back
Aperture setting	manually, pre-set setting ring
Aperture setting range	5.6 to 32 in 1/3 EV steps
Filter/accessory mount	M 95 x 1 and bayonet VIII
Lens shade	Integrated (recessed lens)
Total length	135.6 mm
Maximum diameter	108 mm (w/o tripod mount)
Weight	1110 g
Tripod mount thread	3/8" and 1/4", 360° rotary
Available camera mont	Mamiya / Phase One
Digital back P25+	194 mm x 259 mm
→ Digital back P30+/P40+	175 mm x 234 mm
Digital back P45+	195 mm x 260 mm
Digital back P65+	214 mm x 285 mm

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Recommended base setting of swing/tilt and shift

This section explains how the lens swing or tilt and the parallel lens shift should be set. Their purpose and advantages for improved image quality are described and illustrated from page 8 onward.

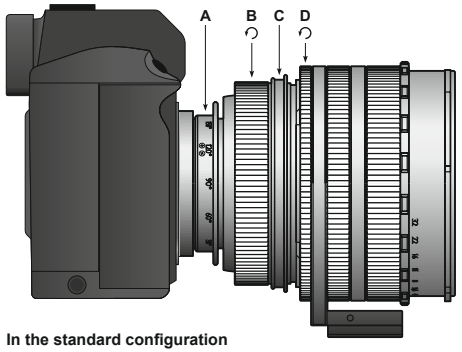
The PC-TS lens should always be stored ready for use in the base setting (untilted, without shift) to ensure ease of use and to avoid errors. The sliding rings **A** (for swing or tilt) and **C** (for shift) should be set, whenever possible, to the angular values for the direction of swing or tilt and shift which are most common in your individual use. The angular value at the ring **A** for the swing or tilt should always be set first because the whole lens is rotated in front of the ring **A** and any shift direction set at the ring **C** (shift) would then change.

The direction of swing or tilt and shift is always the direction in which the angular value 0° faces on both rings.

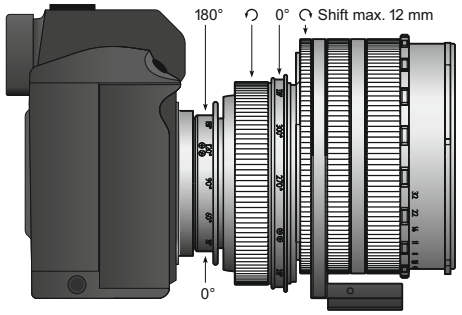
Because the most frequent lens tilt is a downward tilt, the sliding ring **A** should be set so that the angular value **0° is at the bottom**; the angular value 180° can then be read at the top. To allow the sliding ring **A** to be rotated, together with the whole front part of the lens, this ring first has to be pushed forward by around 1 mm and held there. Grip the ring **A** with your thumb and index finger, press it forward at its front bead and turn the whole lens in the desired direction. The ring snaps into the indicated 30° steps when released to prevent any accidental change of the adjustment.

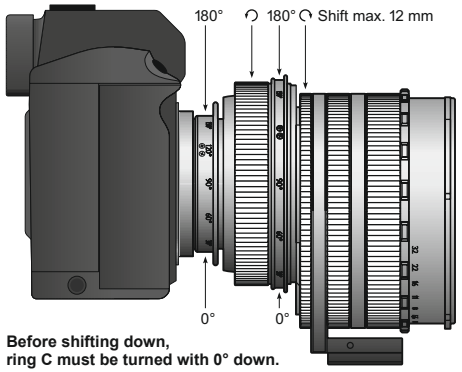
The parallel shift direction which is most common for your purposes will depend on whether you usually shoot subjects in a three-side view holding the camera facing obliquely downward, such as products and packaging for advertising (downward parallel shift) or whether your shoot objects which project far above the horizon, e.g. buildings and architecture (upward parallel shift). Slide the ring **C** about 1 mm forward and at the same time rotate the front part of the lens for downward shift so that the angular value **0° is at the bottom** (or 180° is at the top). For upward shift, in contrast, turn the lens so that **0° is at the top**. Ring **C** also snaps into the displayed 30° steps when released.

If necessary, rotate the tripod collar after loosening the locking bolt so that the **base** is at the bottom again.



In the standard configuration the rings B and D must be turned to the left completely.





Before shifting down, ring C must be turned with 0° down.

Tilt the lens in the selected direction

If both a swing or tilt and a shift of the lens are required, the **swing or tilt direction must always be set first** at the sliding ring **A** and only then the shift direction at ring **C**. The actual tilt movement can be carried out later before or after the shifting. The tilt always takes place in the direction in which the angular value 0° on sliding ring **A** faces.

If a downward tilt is required, the sliding ring **A** should be pressed forward and the lens turned until the value 0° faces down. 180° can then be read at the top.

If the tilt should be to the left, because a surface or wall running close to the camera at the left hand side needs to be in sharp focus from the front to the rear, the lens should be turned so that the value 0° on the sliding ring **A** faces to the left; 270° will then face upward.

Once the tilt direction has been fixed, the tilt angle, that is the magnitude of the tilt, can be set at the rotating ring **B** by turning it clockwise (viewed in the taking direction). The value of the tilt angle can be read off at the area **E** of the rotating ring **B** facing toward the camera above the triangular mark (at 0° or at 180° from ring **A**).

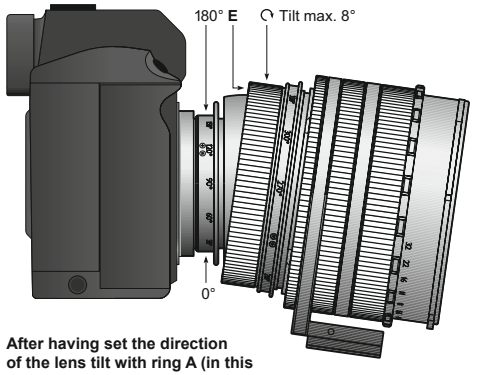
The tilting of the lens always results in a displacement of the plane of optimum sharpness of the subject and therefore in a displacement of the DOF zone surrounding it. It is therefore always necessary to refocus after tilting. The meter scale is not valid with a tilted lens.

See page 10 for a detailed explanation how to find the optimum tilt angle in practice.

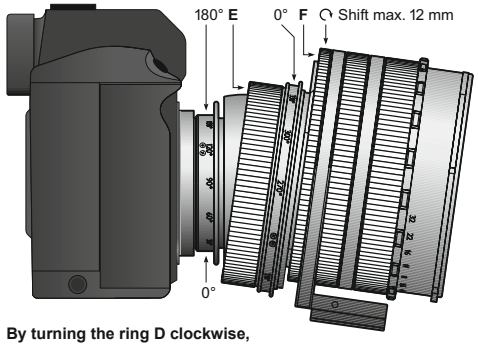
Shift the lens in the selected direction

If the desired direction of the shift has been set e.g. upward for very high buildings (0° at the top of ring **C**) or downward for product shots in a three-side view (0° at the bottom of ring **C**), as described on the left, the required amount of shift can be set by turning the ring **D** clockwise. The displacement path in millimeters can be read off at the area **F** of ring **D** on the camera side. The maximum shift is 12 mm in each direction.

When shifting with a tilted lens, the sharpness will change so that it is always necessary to refocus.



After having set the direction of the lens tilt with ring A (in this picture with 0° downwards), the lens can be tilted up to 8° in this direction by turning the ring B clockwise (seen from the camera side). The tilt angle can be seen on the scale E.



By turning the ring D clockwise, the lens can be shifted into the direction that has been selected before (= in the direction of 0° on ring C, which is upwards in this picture). If the lens has been shifted before tilting the lens, the subject in the frame will be shifted a bit by the lens tilt. Then it may be necessary to correct the field of view by a small additional shift; depending on the focal length and the direction of the lens tilt, an increase or a decrease of the lens shift may be necessary. However, in every case after any tilt and any shift with a tilted lens, the lens must finally be refocused precisely before shoting.

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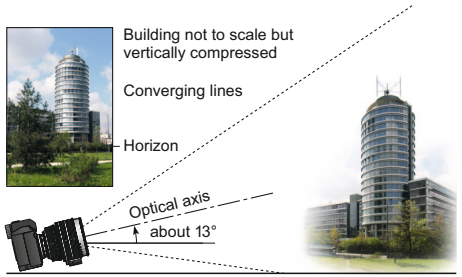
When and why is shifting recommended?

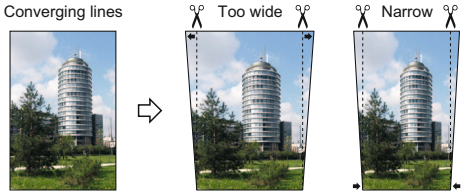
If high buildings are photographed from a short distance away or if products and packagings are photographed from a three-side oblique view, the camera normally has to be pointed upward or downward. The sensor plane or film plane is consequently not parallel to the perpendicular edges of the subject. The subject is therefore imaged as converging upwardly or downwardly like a trapezoid, which is commonly called “converging lines”. The object height is furthermore reproduced in shortened form, that is not correct to scale.

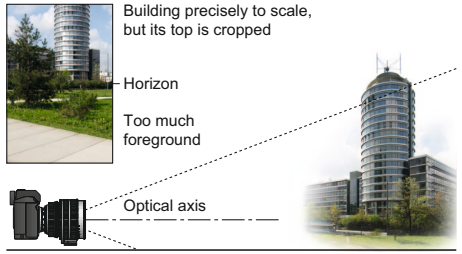
This effect can only be avoided by using a lens with such a large angle of view that the object is completely captured without tilting the lens. So-called shift lenses have such a large angle of view and can be shifted upward, downward, and usually also sideward, relative to the camera body so that the camera can be used without tilting for shots obliquely upward, downward or in any other direction.

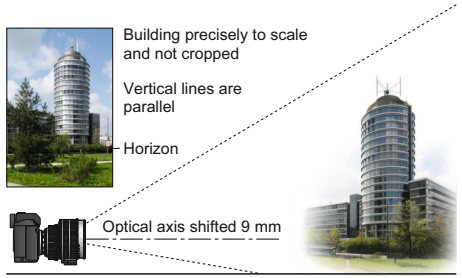
While it is also possible to correct the irritating distortion of converging lines by using image processing software on a computer, this requires a much greater amount of time than by shifting while photographing; it also results in a substantial deterioration of image quality due to the “pixel spread” with subsequent vertical and horizontal interpolation (resolution losses of way over 50 %), and with a parallel orientation of the converging lines, the ratio of width to height changes so that the subject appears vertically compressed or stretched within the image. A vertical distortion correction is therefore required, with a further loss of sharpness due to repeated pixel spread and interpolation in which it is difficult to restore the correct proportions of width to height (the mathematical calculation is very complicated, the procedure is very time-intensive).

This is why adjustable technical cameras are preferred for architecture, industry and product photography because they allow for a correct lens shift to eliminate or attenuate converging lines and to maintain the proportion of width to height. The new Schneider-Kreuznach PC-TS lenses give you the benefits of this shifting with an SLR camera without any post-processing in correct to-scale proportions and without losses in resolution due to pixel spread and interpolation.









Greater depth of field through lens tilt

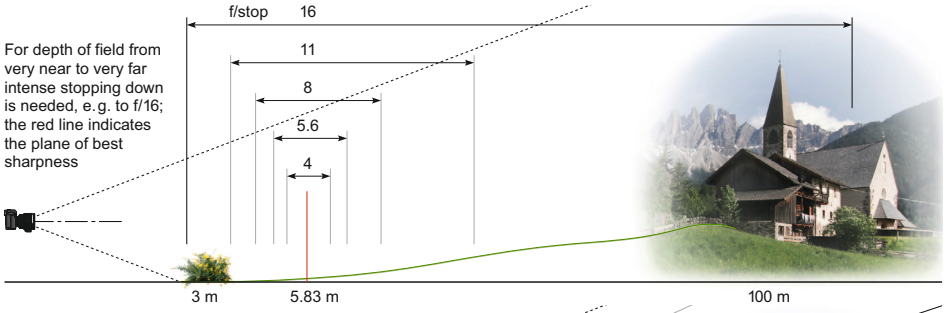
Most subjects are three-dimensional and of varying depth. A perfectly sharp image is, however, only possible for a lens at a distance fixed by focusing on a planar sensor if the object is likewise planar. All details in front or behind this become more and more blurred with increasing distance from this sharpness plane – even more so the further the lens aperture is opened.

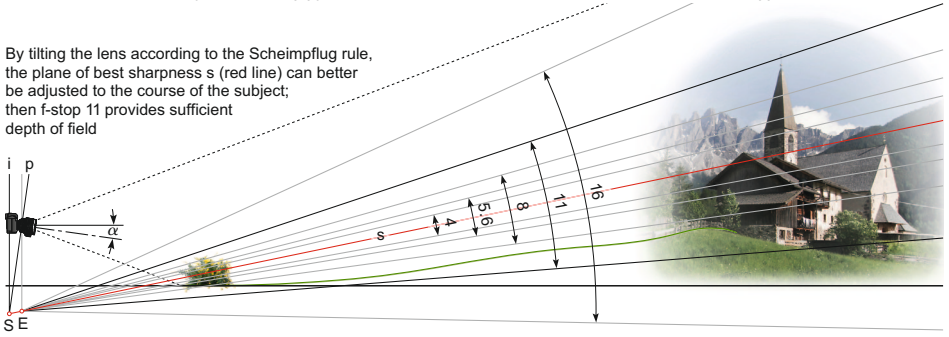
It is therefore normally necessary to stop down by several f/stops for a sufficient depth of field. Unfortunately, the diffraction also increases in an amount critical for high-resolution sensors; this is usually noticeable in full frame 35 mm format from about f/8 or f/11 and in the digital medium format from around f/11 or f/16.

However, lens tilt according to Scheimpflug is a proven way of increasing depth of field while at the same time reducing the required stopping down. The secret of this technique is not a bypassing of physical laws (which is naturally not possible), but rather the tilting of the DOF zone at right angles to the optical axis (top figure) so that the spatial extent of the subject is adapted better (bottom figure).

For this purpose, the lens is tilted by an angle α such that the image-side principal plane **p** of the lens (which can be thought of as the aperture plane in simplified terms) extends through the line of intersection **S** which is formed by the image plane **i** and the Scheimpflug sharpness plane **s** shown in red.

The DOF **zone** included by two parallel planes with a non-tilted lens becomes a DOF **wedge** with the edge **E** in front of the line of intersection **S** on this tilting. The opening angle of this wedge increases almost symmetrically as stopping down increases.





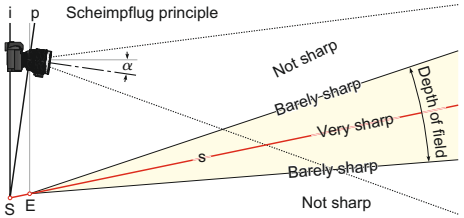
Schneider Kreuznach PC Tilt/Shift Lenses

How to find the Scheimpflug tilt angle

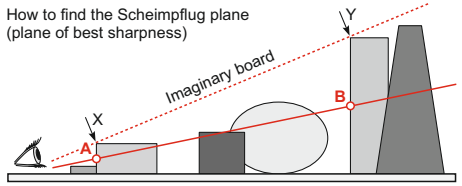
We want to tilt the lens so that the resulting slim depth of field wedge (yellow area in the figure on the right) includes all subject zones to be imaged as sharp. Before we determine the required tilt angle, we first have to find the optimum position of the Scheimpflug plane **s** within the subject as follows:

The subject zone being imaged has to be packed into a wedge between two planes which is as small as possible as in the second figure between the bottom board and a board (imagined to be weightless) placed directly onto the subject. This board would lie on the highest object in the foreground **X** and on the apparently highest object of the background **Y** from the perspective of the foreground (as seen from the eye symbol in the figure on the right and not from the camera). These two objects **X** and **Y** have to be found in the subjec to be imaged as sharp.

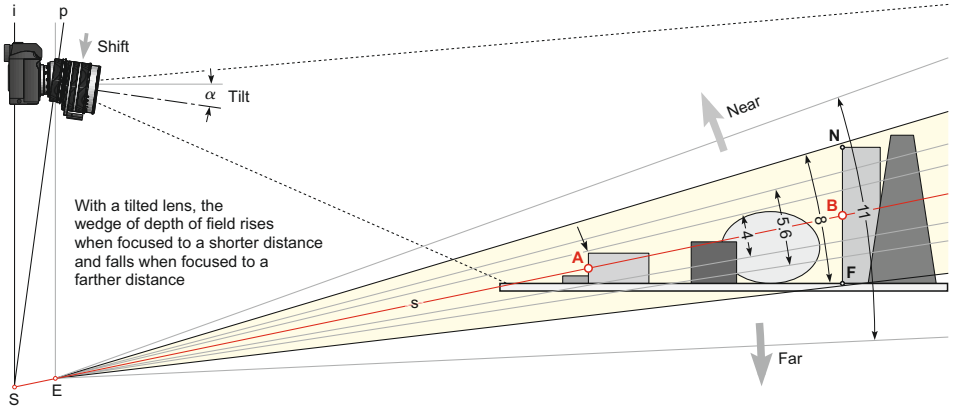
If we now connect the point **A** at half the height of the highest (small) object **X** in the foreground to point **B** at half the height of the apparently highest object **Y** in the background, we have found the course of the ideal Scheimpflug plane for our subject. It is these two points **A** and **B** which therefore have to be imaged as sharp after the tilting of the lens with an open aperture.



Scheimpflug rule: When the lens is tilted, the image plane i, the (image) principal plane p which is close to the aperture plane in most cases and the Scheimpflug plane (= plane of best sharpness) s intersect in a common line S. The depth of field is an almost symmetrical wedge relative to plane S.



To find the optimum Scheimpflug plane (plane of optimum sharpness), look for the highest point X in the foreground and then – seen from this point – look for the apparently highest point Y in the background. If you imagine a board, that loosely lies on the subject, it touches the subject in X and Y. Then you will get two Scheimpflug focusing points A at the half height of X and B on the half height of Y. The Scheimpflug plane runs along a line through A and B.



1. First fix the **pivot direction**. For this purpose, press the rear sliding ring (**A** on page 6) forward and turn the lens so that the angular value 0° faces the foreground of the subject. This will be downward* in most cases.

2. If you want to correct converging lines by shifting, set the front sliding ring (**C** on page 6) for a **shift direction** upward so that the angular value 0° is at the top, for a shift direction downward so that it is at the bottom.

3. Now align the camera with the tripod head so that the sensor plane, and thus also the screen of the **LCD monitor is perpendicular**.

4. Shift the lens (turn the ring **D** on page 6) until you have the desired picture section. If the shift distance of 12 mm is not enough, use the tripod head to tilt the camera a little more until the picture section is correct; the "**residual perspective**" resulting from this is almost always esthetically pleasing (see page 12).

5. Roughly focus on the foreground and tilt the lens by rotating the rearmost rotating ring (**B** on page 6) to

2° on the PC-TS SUPER-ANGULON 2.8/50 HM
3° on the PC-TS MAKRO-SYMMAR 4.5/90 HM
4° on the PC-TS APO-DIGITAR 5.6/120 HM ASPHERIC

6. Focus on point A at half the height of the highest object in the foreground (since the sharpness is always displaced on tilting, you have to refocus after every tilt).

7. Check the sharpness at point B at half the height of the apparently highest object in the background. If this point is already absolutely in focus, you are finished and can continue with step 10.

8. If, however, the apparently highest object H in the background is **sharper above point B**, the tilt angle was still too small. Then, you have to **increase the tilt angle a little**, e.g. by 1° to 2° (depending on how close the best sharpness is to point B) and return to the above step 6.

9. If, however, the apparently highest object H in the background is **sharper below point B**, the tilt angle was already too high. Then, you have to **reduce the tilt angle a little**, e.g. by 1° or even less (if the point of best sharpness is already very close to the point **B**) and again have to return to the above step 6 here.

You will then have finished the Scheimpflug tilt after running through the steps 6 - 7 - 8 or 6 - 7 - 9 (focusing on **A**, checking at **B**, correcting the tilt angle) two or three times.

10. You now only have to **stop down to the correct f/number** for the required depth of field. You can find this by taking test shots in which you check the critical image details **N** and **F** (see figure at the bottom left) on the LCD of the camera or via a connected computer.

11. Point **N** lies on the (near) border of the depth of field wedge at the camera side and is its most blurred point there. Point **F**, as the point furthest away, is the most blurred point at the border remote from the camera. The blur is of equal magnitude at both points. Since we want both points to be "sharp", we have to stop down so far that both appear sharp.

Take a **test shot at aperture 8**, for example. If **N** and **F** are still not sharp at high enlargement, **stop down further** and check the sharpness again. Repeat **until N and F are sharp enough** for your application.

Since memory is no longer expensive, you can alternatively take several shots after one another, e.g. at f/8, f/11, f/16 and f/22 and then (later when you are back at home) take the time you need on a large computer monitor to select that shot in which **N** and **F** have the required sharpness at the widest aperture.

At the end of this process, you will have to stop down less, and thus have less diffraction blur, than would be necessary without a Scheimpflug tilt. You also have the further advantage of a shorter exposure time under available light or less need of flash energy (less expensive flash unit) for flash shots in the photo studio.

* At first glance, it may appear self-explanatory that the foreground always has to be at the bottom. However, if a lateral Scheimpflug swing is carried out e.g. to relocate the sharpness plane to an obliquel house front, the foreground is at the left or right. If e.g. a ceiling fresco is taken obliquely from below and the sharpness is placed in the ceiling, the foreground is at the top.

Schneider Kreuznach PC Tilt/Shift Lenses

What is residual perspective and how do I get it?

If the camera only has a small upward or downward tilt, any converging lines will also be slight. It is, however, still possible to improve the esthetics of an image by correcting the distortion using a shift of an adjustable technical camera or of a shift lens. The steeper the tilt, the more irritating the converging lines and the more important the correction.

If, however, with a very steep upward or downward view, the converging lines are aligned exactly vertically, a tall building will look as if it is becoming wider toward the top. We expect that a very high object becomes smaller at the top where it is further away. It is therefore meaningful not to align converging lines completely parallel, but to leave a slight slant as a “residual perspective” in order to maintain a natural appearance. Test shots with different amounts of keystone correction have shown that a correction of 70 % to 80 %, or a residual perspective of 30 % to 20 %, produces the most natural impression depending on the subject. This leads us to the following recommendation:

You can correct the keystone effect completely by shifting up to around 5 mm in 35 mm format or up to around 8 mm with the larger sensor format of the Mamiya/Phase-One system. If a greater shift is required for a full correction, you should check whether the image might not look better with some residual perspective. It may be a good idea to prepare one completely corrected shot and one with around 25 % residual perspective to allow you to make a later decision on which of the two images is better for your purpose.

You may ask: How do I set 25 % residual perspective?

First perform a full correction with an exactly perpendicular sensor or LCD monitor of the camera. Read off the amount of shift on the scale (**F** in the bottom figure on page 7), e.g. 8 mm. Then reduce the shift by 25 % (this value is half of a half and is so particularly easy to calculate); in our example, this is by 2 mm to only 6 mm. However, this does not give you any residual perspective, only the wrong image section. So you now have to tilt the camera precisely by such a small angle that you have the same image section again as previously with the complete parallel shift of 8 mm. This small tilt gives you the very weak converging lines – enough for a natural effect, but not with so much slant that it looks unnatural.